ADDITIONAL OBSERVATIONS ON THE STRAND FLORA OF NEW JERSEY.

BY JOHN W. HARSHBERGER, PH.D.

The writer presented at some length in the *Proceedings* for 1900 (pp. 623-671) an "Ecological Study of the New Jersey Strand Flora" The supplementary study which is given here represents the material collected in a field study since the publication of the aforementioned brochure. The notes are arranged under several subheads, but, when taken together, they throw additional light upon a region of ecologic interest.

The Strand at Holly Beach.

Holly Beach, situated one mile beyond Wildwood, was visited a second time in August, 1901, for a more extended survey. The beach along the sea front is flat, as at Wildwood, without a sea-dune. The driftwood area in 1901 was very extensive. The tree formation, which is dense at Wildwood, gradually decreases in extent until it disappears at the edge of an extensive salt meadow. Along the edge of the grass-covered meadows, the grass of which was being cut for hay, were found an abundance of the rose mallow, *Hibiscus moscheutos* L., *Kosteletzkya virginica* Gray, *Cassia chamæcrista* L. and *Asclepias incarnata* L. *Cephalanthus occidentalis* L. was noticed in the thicket growth. The meadow was sufficiently high in many places to enable the farmer to cultivate Indian corn, which grew normally in such unusual surroundings.

Forest at Wildwood.

The trees of this forest seem to have reached maturity and are on the decline. This is without doubt due to the removal of the undergrowth from about the trunks of the dominant trees. The soil dries out more quickly under such altered conditions, the wind has better chance to reach the trees and to circulate about them, producing an increased transpiration which proves deadly to the maturer arborescent species that had established a balance between the absorption of water by the roots and the

transpiration of water from the leaves. As an indication of this, the tops of many of the trees have died. "Before Columbus," a cedar mentioned in the first paper, has been injured by the disturbance of this nice balance. "Elliptical" is dead. "United We Stand" is a fanciful name given to two united holly trees. "The Union" is a growth where a cedar and a holly tree have been joined by an ancient natural approach grafting.

The Strand at Sea Side Park.

Observation at this place on the New Jersey shore was conducted in 1901, from August 24 to September 2. *Kosteletzkya virginica* A. Gray was abundant in the converted salt meadow. It opens its flowers for insect pollination early in the morning before 9 o'clock, and closes them about 1 o'clock; for by 2 o'clock the flowers are closed tightly. *Hibiscus moscheutos* L. opens its flowers just after sunrise, and the flowers remain open until about sundown, when the petals begin to roll together. As will be shown in a subsequent paper, this plant shows mutation, and in many respects corroborates the statements of DeVries on the origin of species by mutation.[1] The changes produced in the flora by the grading operations on the upper end of the strand are most marked. *Echinochloa crus-galli* (L.) Beauv. (*Panicum crus-galli* L. var. *hispidum*)[2] was abundant, and associated with this grass in the graded areas of sand *Spartina polystachya* (Michx.) L., *Spartina patens* (Ait.) Muhl.; while as a newly introduced weed, *Linaria linaria* (L.) Karst. (*Linaria vulgaris* Mill.) grew in association with one of the sand grasses, *Sieglingia purpurea* (Walt.) Kuntze (*Tricuspis purpurea* A. Gray). *Mollugo verticillata* L. was found along the railroad in abundance in 1901 and in the dune complex in 1902. Wherever the areas burned over annually were left undisturbed in 1901, there *Rhus copallina* L. grew with the utmost vigor, and this was accentuated in 1902 upon a return to the beach after an absence of a twelvemonth.

The Hibiscus society mentioned in the previous report of the strand at Sea Side Park was found in 1901 to be encroached upon by *Rhus copallina* L. and *Scirpus debilis* L., so that an admixture of these plants took the place of the pure growth of the rose mallow.

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[1] DeVries, *Die Mutationstheorie.*

[2] Names after Britton, *Manual of the Flora of the U. S. and Canada.*

The following plants were noted upon the beach along Barnegat Bay, near the Island Beach Life Saving Station, in 1901, viz., *Mollugo verticillata* L., *Echinochloa crus-galli* (L.) Beauv. (*Panicum crus-galli* var. *hispidum*), *Cyperus strigosus* L. and *Erechtites hieracifolia* (L) Raf. Wherever the wind acts with its full transporting power in the dune complex, the dunes of which are held in place by *Myrica cerifera* L., *Ammophila arenaria* (L.) Link, *Hudsonia tomentosa* Nutt., *Prunus maritima* Wang and

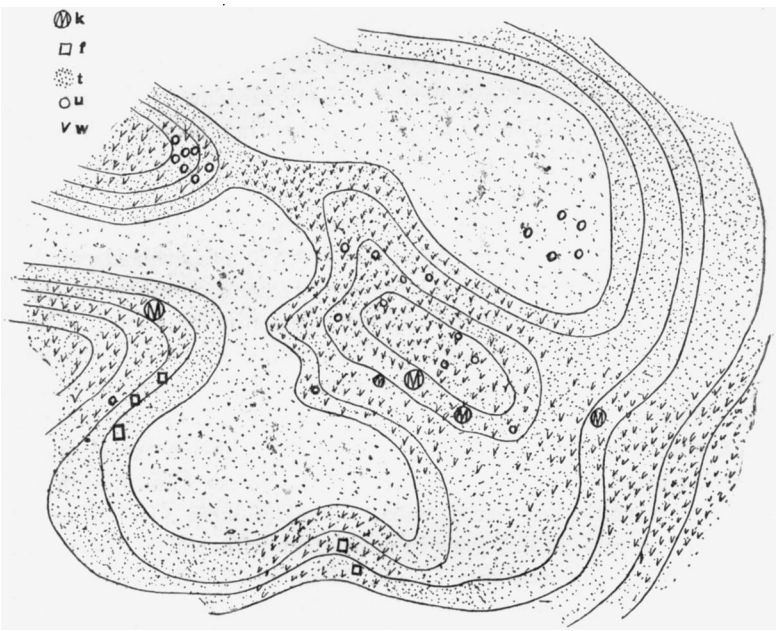

Fig. 1.

k. *Myrica cerifera* L.; f. *Hudsonia tomentosa* Nutt.; t. Pure sand.; u. *Solidago sempervirens* L.; w. *Ammophila arenaria* (L.) Link.

Rhus radicans L., there the sand is scooped out and carried away with the formation of a dune hollow, into the bottom of which the ground water rises by seepage. The steps in this process can be followed at South Sea Side Park. A dune valley, which has not been brought down to the level of the ground water, may consist of pure sand bottom and sides without vegetation, or if plants be present, they are confined to the area of drifted sand and not to the area that is wind-swept. In such a hollow, the drifted sand

supports, as shown in fig. 1, three character plants, viz., *Myrica cerifera* L., *Solidago sempervirens* L. and *Hudsonia tomentosa* Nutt. The sides of the irregular basin not wind-swept support the marram grass, *Ammophila arenaria* (L.) Link, *Solidago sempervirens* L., *Hudsonia tomentosa* Nutt., and an occasional clump of wax-berry, *Myrica cerifera* L. If the sand is still farther transported by the wind, there remain hillocks of dry sand in the center of a level damp stretch on the level of the ground water. Sometimes the bottom of the hollow forms a level trough of wet sand, surrounded by sun-dried sand on all sides. Such a hollow, illus-

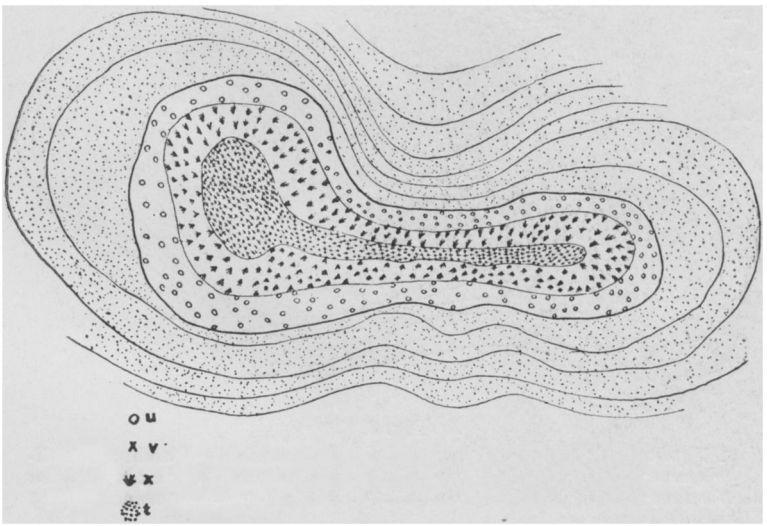

Fig. 2.

u. *Solidago sempervirens* L.; v. *Scirpus debilis* Pursh; x. *Panicum virgatum L.*; t. Pure sand.

trated in the accompanying figure (fig. 2), is tenanted by three character plants. The wet sand supports a continuous growth of *Scirpus debilis* L.; the side of the dune trough, *Panicum virgatum* L., a grass which may be called a tussock grass, because it does not form a continuous turf, but grows in clumps more or less isolated from each other. In the higher drier sand of the depression, before the slopes of the dunes of the dune complex are reached, there grows a character plant, *Solidago sempervirens* L. We have, therefore, a replacement of the original dune occupants,

viz., *Ammophila arenaria* (L.) Link, *Hudsonia tomentosa* Nutt., *Myrica cerifera* L. etc., by three plants, *Scirpus debilis* L., *Panicum virgatum* L. and *Solidago sempervirens* L. If this process is carried still farther, then we have a large number of marsh-loving species appearing in the wet sand of the basin-shaped or elongated depression. The following figure (fig. 3) shows such a dune val-

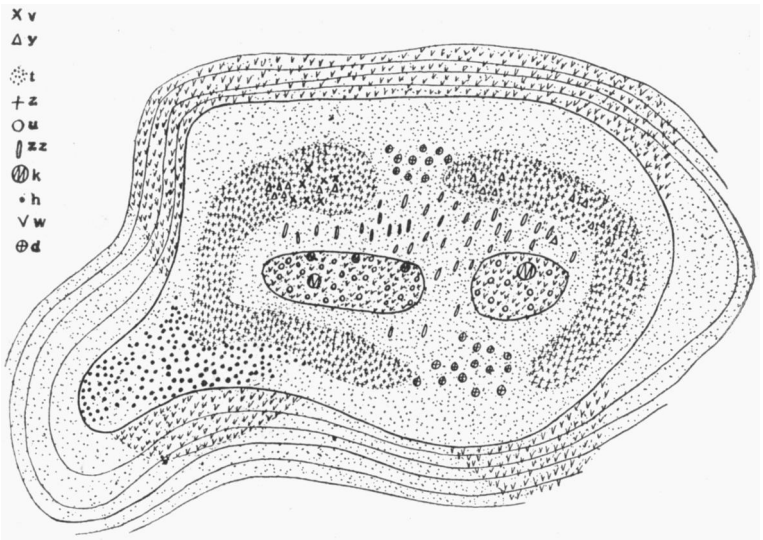

Fig. 3.

y. *Typha latifolia* L.; t. Pure sand; z. *Scirpus debilis* Pursh.; u. *Solidago sempervirens* L.; zz. *Euthamia caroliniana* (L.) Greene; k. *Myrica cerifera* L.; h. *Cyperus nuttallii* Eddy; w. *Ammophila arenaria* (L.) Link; d. *Juncus* sp.

ley, the bottom of which is wet by the seepage of the ground water through the sand. The lower damp, marshy places are covered with a growth of *Scirpus debilis* L., from which arises *Typha latifolia* L. and a tall sedge, *Scirpus sylvaticus* L. The higher still damp areas support *Cyperus nuttallii* Eddy and *Juncus* sp., although these two plants are, as a rule, not found in association. The islands, or knolls of sand, which remain in the marshy area are held in situ by *Myrica cerifera* L., *Ammophila arenaria* (L.) Link and *Solidago sempervirens* L. These three plants grow together side by side. *Euthamia caroliniana* (L.) Greene (*Solidago tenuifolia* Pursh.) is found where the sand is damp. The sand marsh is

fringed directly with *Ammophila arenaria* (L.) Link, *Solidago sempervirens* L. and an occasional *Myrica* berry, while outside of these the slopes of the dunes are wind-swept and destitute of vegetation. In the degradation of a dune and the formation of a wind-swept hollow, we have a succession of societies which are approaching the ultimate state, that of a mesophytic thicket. The transition, noticed in the dune complex at Sea Side Park, is from an intensely xerophytic association of species to marsh-dwelling xerophytes, and from these in turn to xerophytic shrubs and trees culminating in a mesophytic thicket filling the extent of the original dune valley.

The annexed figure (fig. 4) illustrates a xerophytic marsh associa-

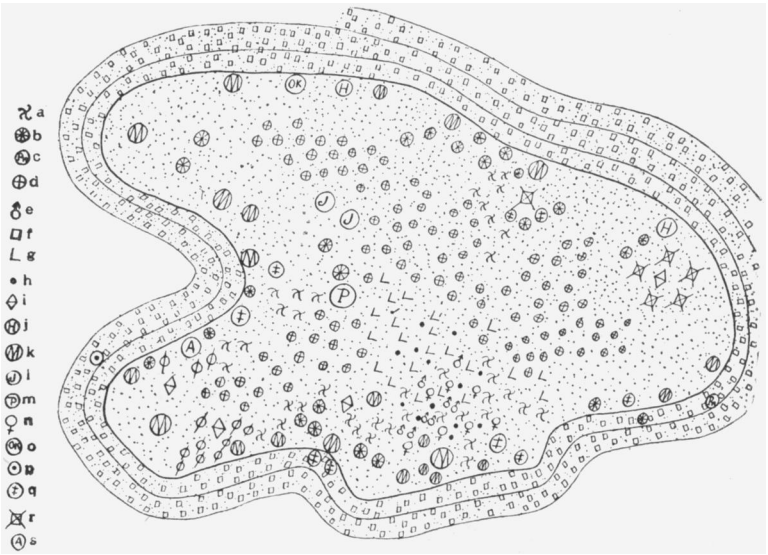

Fig. 4.

a. *Oxycoccus macrocarpus* (Ait.) Pers.; b. *Vaccinium corymbosum* L. and *Gaylussacia resinosa* (Ait.) T. & G.; c. *Panicum virgatum* L.; d. *Juncus* sp.; e. *Drosera rotundifolia* L.: f. *Hudsonia tomentosa* Nutt.; g. *Lycopodium carolinianum* L.; h. *Pogonia ophioglossoides* (L.) Ker.; i. *Ilex glabra* (L.) A. Gray; j. *Ilex opaca* Ait.; k. *Myrica cerifera* L.; l. *Juniperus virginiana* L.; m. *Pinus rigida* Mill.; n. *Drosera filiformis* Raf.; o. *Quercus minor* (Marsh) Sarg.; p. *Andropogon virginicus* L.; q. *Kalmia augustifolia* L.; r. *Chamæcyparis thyoides* (L.) B. S. P.; s. *Acer rubrum* L.

tion in the transverse dune complex at Sea Side Park, surrounded

by the encroaching army of shrubs and trees of xerophytic habit in the stage before the culminating one, the mesophytic thicket. The mesophytic thicket at South Sea Side Park occupies from what has gone before the hollows, or rounded depressions in the dune complex, and in its simplest make-up consists of the two following associations of species: One thicket examined consists of *Pinus rigida* Mill., *Sassafras sassafras* (L.) Karst., *Vaccinium corymbosum* L., *Juniperus virginiana* L., *Chamæcyparis thyoides* (L.) B. S. P. and *Myrica cerifera* L.. Another hollow contains *Ilex opaca* Ait., *Juniperus virginiana* L., *Prunus maritima* Wang, while, as an undergrowth, associated together, are *Rhus radicans* L. and *Solidago sempervirens* L.

Either before the final condition is reached, or after such thickets have been formed, the original condition of the dune complex may be restored by the drifting in of the sand into the depression, resulting in a destruction of the long-established plant societies. Such vicissitudes in the life history of plant societies are not common, although examples are found occasionally on the New Jersey strand. As a rule, before the final culmination of dune hollow history is reached, the elevated sand hills surrounding it are captured by sand-binding plants, such as *Ammophila arenaria* (L.) Link, but especially *Hudsonia tomentosa* Nutt., which forms heaths about the depression, effectually preventing the transport of the sand and its deposition in the basin-shaped valleys adjoining. In case the sand is transported, it begins to fill up the dune valley through the action of the oceanic flotsam and jetsam. The accumulation of such material in the storm-washed waterways between the dunes has gone on for ages. Before the advent of civilized man, the material washed ashore consisted of the trunks and limbs of trees, seaweed, leaves and the floatable objects carried to sea by the rivers. Since the occupation of the shore by white men, the flotsam and jetsam consists of a remarkable collection of nondescript rubbish, such as ship timbers, chips of wood, broken boards, spars of boats, sides of rowboats, old cots, mattresses, bottles, and, in fact, anything and everything used by man that is floatable and can stand the action of salt water for months at a time.

The piling up of such rubbish in the dune complex acts as an effective means of binding the sand and preventing its drifting.

Soon about such objects the sand begins to form a dune, which grows larger and higher as the seasons pass until it is covered by the marram grass which binds it. A new washway may be made around this newly formed dune and the drift of previous years may be uncovered. The writer believes that if a trench were dug for a mile or two along the beach and paralleling the ocean, a distinct stratum of rubbish would be revealed, if the excavation was made deep enough to reach the level above the ground water.

The presence of so much wood undergoing decay accounts for the growth of the fungi found by the writer growing in the pure (?) sand of the dune complex. *Astræus stellatus* is common. *Thelephora terrestris* Fr. is found growing about the stems of *Hudsonia tomentosa* Nutt. The puffball, *Lycoperdon turneri* E. and E., was found associated with these, while *Clitocybe trullisata* Ellis, found with largely developed base and small pileus, indicates, according to Prof. Peck who identified it, something unusual in the conditions of growth. *Fuligo* (*Æthalium*) *septica* Gmel., a myxomycete, is found commonly attached to decaying driftwood.

Several new plants were found in 1902 growing in close contiguity with the objects drifted in through the oceanic spillways. *Artemisia stelleriana* Bess., reported previously from eastern Massachusetts and Sandy Hook, was found. *Rumex acetosella* L. and *Helianthus* sp. were also collected in such situations. Only one conclusion can be drawn from their presence, namely, that their seeds were washed ashore with the rubbish mentioned.

The thicket formation on the strand a mile below the Island Beach Life Saving Station perceptibly narrows its width. At the Island Beach Life Saving Station it forms a broad band of vegetation, but below this point it is nowhere over a hundred yards wide and is confined to the more sheltered bay side of Barnegat peninsula. Between the thicket formation and the narrow forest, the dune complex forms the dominant feature of the landscape, except where a slue or thoroughfare enters the beach from the bay side. At one place the strand is so narrow where this slue extends, that during heavy storms in winter the ocean and bay meet, cutting the strand into islands more or less separated from each other. *Scirpus lacustris* L is the character plant along the edge of this slue, and where the slue becomes a marsh this plant forms pure societies. Where the ground becomes firmer, social groups of

Hibiscus moscheutos L. hold sway, while on the higher ground along the borders *Baccharis halimifolia* L., *Rhus copallina* L. and *Myrica cerifera* L. occur.

The importance of these slues and the corresponding channels or spillways cut into the dune complex during the heavy storms of winter, when bay and ocean may be said to unite, is evident upon careful consideration. Barnegat Bay and many similar ones along the Jersey coast are practically free from aquatic vegetation, such as *Zostera marina* L., *Fucus vesiculosus* L., *Vallisneria spiralis* L., etc., which may contribute material to fill up the bay with vegetal detritus. The water in physical constitution oscillates between two extremes, salt and fresh. If the barrier between the sea and the lagoon is at times closed, so that the water in the bays becomes fresh, the result is that plants which are especially adapted to the production of salt marshes are killed by the fresh waters, while the occasional invasion of salt water during storms by way of the dune hollows and stronger tides through the inlets destroys the fresh-water plants, which might otherwise establish a swamp of their species. By these alternations some of the largest bays have been kept open, although in many places shallow in the extreme. *Ruppia maritima* L., as it grows in Barnegat Bay, seems to be the only species which has succeeded in adapting itself to such fluctuating conditions. It has been referred to as the character plant of the shallower waters of that bay, and with the consideration of the above facts its probable future rôle in preparing the way for other adaptive hydrophytes becomes evident.

Ludlam and Seven Mile Beaches.

Strictly speaking, a beach is that part of a shore between high and low water, but in New Jersey the term is applied to what are really sea islands. Ludlam Beach, on which Sea Isle City is located, extends from Corson's Inlet to Townsend's Inlet. Except at a point below Sea Isle City, the beach is almost on a level, and during a violent storm it is likely to be entirely submerged, especially at high tide. The dunes that exist below the town are much cut up. *Ammophila arenaria* (L.) Link dominates the foreground along the beach. The Myrica thicket exists on the dune complex associated with *Baccharis halimifolia* L. and *Rhus radicans* L. The highest dunes on Ludlam Beach, at Life Saving

Station No. 34, have a few cedars and stand some distance back from the ocean front, and this disposition of dunes is most marked at Townsend's Inlet, where they encroach on the extensive salt meadows.

Crossing Townsend's Inlet, Seven-Mile Beach is reached with the highest sea dunes on the whole New Jersey coast. This beach, settled upon in 1788,[3] was not investigated ecologically prior to the summer of 1901. A description of the flora was not incorporated, therefore, in my paper published in 1900. Passing Avalon, the highest dunes (forty-two feet) are found close to the sea front. The dunes are held in place by *Ammophila arenaria* (L.) Link, and where the dune has encroached on the forest an occasional dead tree may be seen sticking out from the dune surface. Beyond Piermont, the district of Seven-Mile Beach studied by the writer is reached. The dunes fronting the ocean half-way between Stone Harbor and Piermont are rounded knolls about six to ten feet high covered with marram grass, *Ammophila arenaria* (L.) Link. The beach at low tide is extremely flat, and by the appearance of the sand may be divided into three zonal areas: (1) The firm, hard beach covered at high tide with salt water; (2) a higher beach with dry, loose, drifted sand held in place by driftwood; (3) the wet beach filled at high tide by pools of water. The two latter areas comprise the middle beach of my previous paper. The upper beach is characterized by scattered patches of sea blite, *Cakile edentula* (Bigel.) Hook, and *Ammodenia peploides* (L.) Rupr , which forms rounded annual or temporary dunes. Here and there channels have been cut into the low dunes which are hardly worthy of the name, so that at high water the tide runs back to the meadows behind. Several of these cuts occur meeting marshy places behind, surrounded by dunes on the seaward side of the railroad. On the exposed sand of these depressions *Portulaca oleracea* L. grows, and on their edge creeps *Strophostyles helvola* (L.) Britton. Just before the channel joins the marshy areas a large amphitheatre of barren wet sand is found, fringed by *Scirpus lacustris* L., *Atriplex arenaria* Nott., *Salicornia herbacea* L., *Portulaca oleracea* L., outside of which character plants in concentric circles, *Strophostyles helvola* (L.) Britton,

[3] The house built then stood in Piermont, at Second avenue and Thirty-first street.

Pluchea camphorata (L.) D.C., *Cenchrus tribuloides* L., *Euphorbia polygonifolia* L., *Xanthium canadense* Mill. This society may be said to be dominated by *Strophostyles helvola* (L.) Britton. In the standing water grows in hammocky places *Spartina stricta* (Ait.) Roth. These hammocks catch the blowing sand and are destined to become dune islands. Such a dune island in the midst of a marsh was covered by *Spartina patens* (Ait.) Muhl., killed on one side by the sand blast.

Nearer Piermont, the physiography of the beach changes and the marked feature of this region is the height of the dunes and the absence of marshes and pools of water in the dune complex. The sea beach here is flat and about one hundred feet wide. The same zonal areas of lower and middle beach are present. The upper beach facing the dunes is flat and covered by *Salsola kali* L., *Cakile edentula* (Bigel) Hook and *Xanthium canadense* Mill. The frontal dune is ten feet high, sloping on the windward or land side. Upon it grow *Ammophila arenaria* (L) Link., *Cenchrus tribuloides* L., *Sieglingia purpurea* (Walt) Kuntze. The Myrica zone is absent in the hollows back of this dune. Its place is taken by the social groups of *Strophostyles helvola* (L.) Britton which forms dark-green mats. In the deeper hollows, *Gerardia maritima* Raf. and *Euphorbia polygonifolia* L may be called character plants. The dune complex is undulating with rising hills of sand, covered on the seaward side by *Strophostyles* and on the landward slope are *Solidago sempervirens* L. and occasional clumps of *Myrica cerifera* L., not dominant; *Œnothera humifusa* Nutt., *Baccharis halimifolia* L. and *Andropogon virginicus* L. Across the area controlled by these herbaceous plants, the barren wind-swept zone is reached upon which no vegetation grows except the marram grass, *Ammophila arenaria* (L.) Link, an occasional red cedar, and as rare plants, *Phytolaca decandra* L. and *Euphorbia polygonifolia* L. Dead trees stand up out of the sand over this zone, which is about six hundred feet wide. The high dunes (40–50 feet) are reached by gradual ascent after crossing the area devastated of its trees by the drifting in of the sand. These high dunes are abrupt on the landward side, where they encroach on the dense deciduous forest behind. This forest seems doomed to extinction, if the past history of these dunes is followed in the dead trees of the wind-swept area. Not many years ago this forest was

some five hundred feet wider than at present, and by the relentless, unrestrained activity of the drifting sand it has been slowly, but surely, engulfed. It is a peculiar scene from the top of this dune: on the land side there is a dense mass of dark-green foliage, beyond which there is the broad expanse of green salt meadows with their bays and thoroughfares.[4] The sand which has formed these dunes comes fresh from the great ocean mill, ascends the surface of the dune and falls over its crest into the forest. When a stiff breeze is blowing it skims along like drifting snow, sufficiently strong to lacerate the skin, trimming the tops of the trees as flat as though shorn with shears The writer is of the opinion that the shapes of the trees along our coast is due more to the sand blast than to the direct action of the wind.

Gifford[5] describes the formation of these dunes: "If the forests are what cause the dunes, by preventing the west wind from blowing back the sand, how did the forests form? Single trees here and there, or groups of trees, which are clean underneath, so that the west wind sweeps through without serious interruption, do not cause the formation of dunes. In the course of time, however, a thicket forms under these trees. They become covered with grapevines, Virginia creepers and greenbriers. The birds and the wind scatter the seeds of many sorts of shrubs and bushes, such as *Prunus maritima*, sweet gale, *Baccharis halimifolia*, etc., until a dense forest is formed through which the west wind cannot penetrate, the consequence of which, in the course of time, is a dune, which in turn finally engulfs and kills the forest that had caused it." The forest which is being destroyed consists of the red cedar, *Juniperus virginiana* L., holly, *Ilex opaca* Ait., black gum, *Nyssa sylvatica* Marsh, wild cherry, *Prunus serotina* Ehrh., *Quercus lyrata* Walt., hackberry, *Celtis occidentalis* L., willow oak, *Quercus phellos* L., swamp maple, *Acer rubrum* L., persimmon, *Diospyros virginiana* L., pitch pine, *Pinus rigida* Mill., red mulberry, *Morus rubra* L., while as lianes may be mentioned *Parthenocissus* (*Ampelopsis*) *quinquefolia* (L.) Planch., *Vitis labrusca* L., *Vitis æstivalis* Michx., *Tecoma radicans* (L.) D.C., which reminds one of the dunes of the seashore of eastern Virginia, where the trumpet

[4] A thoroughfare is a waterway or channel from one bay to another along the New Jersey coast.

[5] GIFFORD, *Annual Rep. State Geologist of New Jersey*, 1899, "Report on Forests," p. 251.

creeper abounds and *Smilax rotundifolia* L. As the sand blows in about the trees, these lianes are covered up with the trees until the tops of the trees only are exposed. The lianes then take root and spread out in all directions circumferentially a distance of many feet from the tree which, now dead, formerly supported them. The lianes, therefore, began their life-history on the lower level ground and conclude their growth on the surface of the sand dune fifty feet above where they first took root—veritable vegetal Jacks-and-the-Bean Stalk. This curious biologic feature, never before mentioned, to the knowledge of the writer, in connection with the life-history of a sand dune, is exemplified on all of the higher sand hills at Piermont.

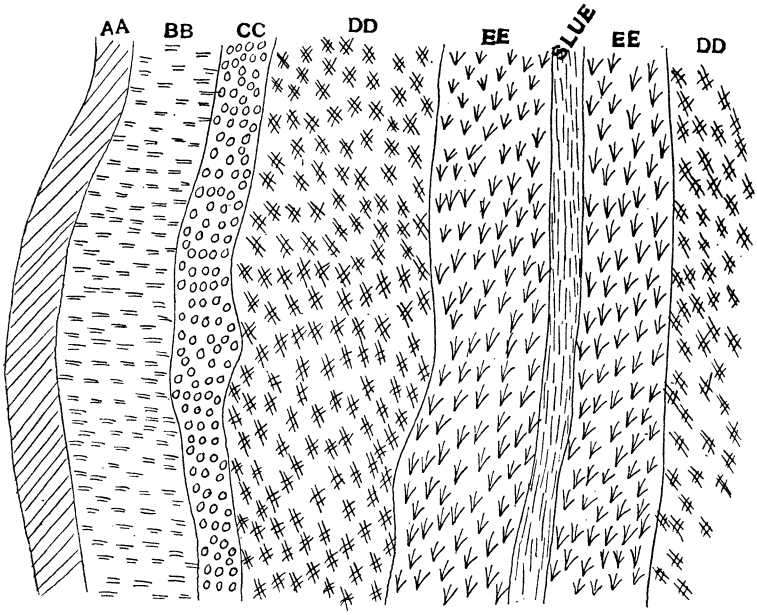

Fig. 5.

AA. Zone of *Hibiscus moscheutos* L., *Panicum virgatum* L.: BB. Zone of *Distichlis spicata* (L.) Greene, mature; CC. Zone of *Distichlis spicata* (L.) Greene, less mature; DD. Zone of *Salicornia herbacea* L., *Salicornia Bigelovii* Torr., *Spartina patens* (Ait.) Muhl., *Limonium carolinianum* (Walt.) Britton.; EE. Zone of *Spartina stricta* (Ait.) Roth.

On the ground in the forest the botanist finds *Mitchella repens* L., *Rhus radicans* L., etc. Crossing the railroad, which runs through

the forest at this place, a strip of higher ground runs out some distance upon the meadow. The tension lines are well demarcated here. *Juniperus virginiana* L. is the only tree which borders directly the salt marsh. A rounded dune occurs on the edge of the marsh. From it a closer prospect of the salt marsh is to be had. *Juniperus virginiana* L., *Rhus glabra* L., *Myrica cerifera* L., *Sassafras sassafras* (L.) Karst., *Ilex opaca* Ait., *Rhus radicans* L., with the climbing *Willoughbœa scandens* (L.) Kuntze form the vegetal covering of this eminence. The outer zone of the salt marsh is characterized by the presence of *Hibiscus moscheutos* L. On the marsh proper occurs in several well-marked zones *Distichlis maritima* (L.) Greene in the more elevated portions, while *Salicornia herbacea* L., *S. bigelovii* Torr., *Spartina patens* (Ait.) Muhl., and *Limonium carolinianum* (Walt.) Britton grow in the wetter areas. Along the edge of the thoroughfare[6] through which the tidal water circulates is found a pure association of *Spartina stricta* (Ait.) Roth. The accompanying figure (fig. 5) shows the zonal distribution of the salt-marsh plants on Seven-Mile Beach. Near the outer edge of the marsh *Hydrocotyle umbellata* L. is found, while on exposed sand slopes *Opuntia opuntia* (L.) Coult. is at home with a rose and a willow forming nearby thickets.

Comparison of the Dunes at Piermont and at Sea Side Park.

The dune formation of the New Jersey coast, as previously mentioned, reaches its culmination at Piermont, where sand hills forty to fifty feet high are met with. The western slope of the dunes at Piermont are precipitous, while the eastern slope (a gradual incline) grades off into the lower dunes of the dune complex. The dunes at Sea Side Park range in elevation from ten to twenty feet, and the eastward or seaward slope is much the steepest. The causes which have brought about this difference are the following: The wave-made embankments on the sandy beaches differ in their form and in the conditions of their construction from those which are made up of pebbles.[7] The sand, owing to the fineness of its grains, is easily blown about by the wind. When the tide retires, a broad expanse of this material is left for some hours exposed to the sun. The surface dries, and the gales from

[6] Also spelled thorofare.
[7] Cf. Shaler, *Sea and Land*, pp. 49–51.

the sea sweep the particles up the slope until they arrive at the crest wall, where they are caught in the tangle of beach grasses and other plants, and are protected from the currents of air. When the movement of sand is most rapid, it may bury these plants out of sight, but most of them are tolerant of this covering of sand, and quickly grow upward and make a new entanglement for the moving sand. Such plants are *Ammophila arenaria* (L.) Link, *Prunus maritima* Wang. and others previously described. In this manner, the crest of the beach grows upward and the lee slope of the sand hill is always the steepest one. The dunes of the New Jersey coast are not so marked as some in other parts of the world (as, for example, at Eccles, in England, where one of these dunes in the last century invaded the village and buried the dwellings and the parish church so that even the top of the spire was hidden) for the reason that the prevailing winds of New Jersey are from the west; and the sand swept up from the sea-margin by the ocean storms and easterly breezes is, to a great extent, carried back by the off-shore winds. Even these dunes would have a precarious existence were it not for the fact that the vegetation, generally quite luxuriant, holds the sand in place. The prevalent west winds and the absence of protecting trees account for the character of the dunes at Sea Side Park, where the frontal dune slopes gradually up from the windward or landward side to the crest of the dune, the leeward or ocean side being quite steep and declivitous.

At Piermont, on the contrary, the western or windward slope of the dune is the steepest. Here a forest, formerly five hundred feet wider, is being engulfed by the drifting sand. The sand, carried by eddies of the prevailing western winds, but more especially by the winds of ocean storms, ascends the surface of the dune and falls over its crest into the forest. When a stiff breeze is blowing, the sand skims along like drifting snow sufficiently strong to decorticate trees. The forest, choked with undergrowth composed of climbing plants and shrubs, as previously mentioned, prevents the access of the western breezes that are prevalent and which are inimical to dune upbuilding, and the sand, therefore, moves relentlessly carried by the eastern winds that now and then blow upon the forest that engendered the dune. The presence of this forest, therefore, explains the peculiarities of the dune formation at Piermont, as contrasted with that at Sea Side Park.

The Absecon (Atlantic City) Beach Strand.

Dr. Thomas S. Githens has furnished me with the results of some observations upon the flora of Absecon Beach. The coast in the neighborhood of Atlantic City is occupied largely by human habitations, so that the flora has been modified except at several places about two to four miles south of Absecon Inlet. The geography of the island may be shown by the accompanying diagrams in fig. 6.

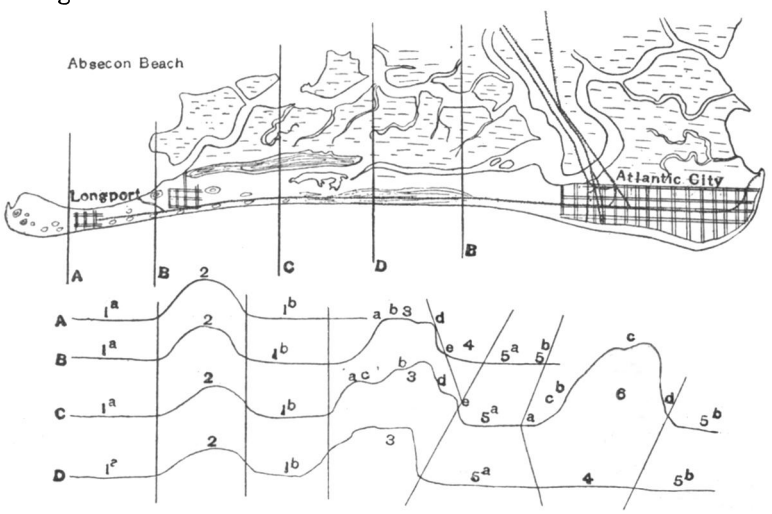

Fig. 6.

The upper figure is an outline map of Absecon Beach with the ecologic lines A, B, C, D drawn across it. The lower figure represents cross-sections of the beach along the lines A, B, C, D, and shows the relative elevations along each line. The letters and numerals designate different zonal areas, where the plants designated by similar numerals are referred to the several zones in the accompanying list, made by Dr. Thomas S. Githens.

The region, botanically considered, has been divided by Dr. Githens in his notes[8] as follows:

Area I.—Beach.

Zone (*a*)—Tide Beach.

Zone (*b*)—Second Beach.

[8] These notes confirm the observations of the writer, published in the *Proceedings of the Academy of Natural Sciences of Philadelphia* for 1900, but the terminology is somewhat different.

Area II.—Low Dunes.
Area III.—High Dunes.
Zone (*a*)—Juniper Thickets.
Zone (*b*)—Myrica Thickets.
Zone (*c*)—Hudsonia Formation (bare places).
Zone (*d*)—Ilex Thicket.
Zone (*e*)—Border of Marsh.
Area IV.—Sand Flats (always damp).
Area V.—Marsh.
Zone (*a*)—Drier Marsh.
Zone (*b*)—Boggy Marsh.
Zone (*c*)—Tidal Flats.
Zone (*d*)—Lakes and Thoroughfares.
Zone (*e*)—Thoroughfare Borders.
Area VI.—Island.
Zone (*a*)—Marsh Border.
Zone (*b*)—Treeless Space.
Zone (*c*)—Wood.
Zone (*d*)—Back Marsh Border.
Area VII.—Made Land.

It will be observed that the author of the notes confuses botanical and physiographic features. The classification should be either based on the floral make-up of the region, or be arranged according to its physiography. Thus, for example, this botanist has juniper thickets and dry marsh and boggy marsh zones. Barring these inadvertencies the classification of areas is a natural one. The first beach, according to Dr Githens, supports no plants except occasionally *Cakile edentula* (Bigel.) Hook. The outer (Low Dune) is held in place by the character grass (*Ammophila arenaria* (L.) Link). The outer edge of the dune complex (Second Beach) is occupied by the Atlantic City and Longport Railroad, but in places *Cakile edentula* (Bigel.) Hook., *Ammophila arenaria* (L.) Link, *Cenchrus tribuloides* L, *Salsola kali* L. are found. The captured dunes (High Dunes of the classification) are covered with thickets of *Juniperus virginiana* L. and *Myrica cerifera* L., interspersed with bare spaces on which *Hudsonia tomentosa* Nutt., as a character plant, grows. *Prunus maritima* Wang. and *P. virginiana* L. grow in all the sheltered places. The landward

slope is characterized by the presence of holly, *Ilex opaca* Ait., the height of the dune being determined by the height of the protecting trees, *i.e.*, twenty-five feet. The island is about two miles long, and is set in the middle of the marsh about half a mile inland from the high dunes. It is covered mainly by pine and oak trees which are quite large on its highest parts. Inside of this marsh island there is a comparatively dry marsh, in which all plants except grasses, rushes and sedges do better than in the larger marsh outside. At the ends of this island in the marsh, and on the landward side, are low-lying sandy plains, low enough to be saturated at high tide with salt water and which support a characteristic growth of *Buda* and similar succulent species. In the list, which is rather cumbersome, the numbers refer to the areas marked on the map represented in fig. 6, and the lower-case letters of the alphabet refer to the zones into which the several areas are divided. The plants, therefore, in the list occur in the areas and zones designated. A dagger (†) signifies that the plant is represented in the herbarium of Dr. Githens. The plants in the list are named according to the sixth edition of Gray's *Manual,* but for convenience of reference the writer, who has edited the notes of Dr. Githens, has added the names found in Britton's *Manual of the North United States and Canada.* The orders follow the sequence of Engler and Prantl's *Die Natürlichen Pflanzenfamilien.* The plants not given in the list published in "An Ecological Study of the New Jersey Strand Flora"[9] are designated by an asterisk.

The commingling of the plants of different zones may be represented as follows:

II to I*a* and I*b*.
III to II and I*b*.
V to IV.
III*e* to IV and V.
VI to V*e*.
VI*d* to V.

LIST OF SPECIES AND ZONES OCCUPIED BY THEM.

VI*c*. *Pinus rigida* Mill.
III*a*. *Juniperus virginiana* L.

[9] *Proc. Acad. Nat. Sci. Phila.*, 1900, pp. 661-671.

V*a*.	*Typha latifolia* L.
V*a*.	*Typha angustifolia* L.
V*d*†.	*Ruppia maritima* L.
V*d*.	*Zostera marina* L.
II.	*Ammophila arundinacea* Hast. (*Ammophila arenaria* (L.) Link).
I, II, IV†.	*Cenchrus tribuloides* L.
V*a*†.	*Panicum crus-galli* L. (*Echinochloa crus galli* (L.) Beauv.).
V*a*†.	*Panicum proliferum* Lam.
*V*a*†.	*Panicum sanguinale* L. (*Syntherisma sanguinalis* (L.) Nash).
V*a*†.	*Panicum virgatum* L.
*V†.	*Setaria glauca* Beauv.
V.	*Spartina cynosuroides* [L.] Willd.
V†.	*Carex straminea* Willd.
V†.	*Cyperus nuttallii* Torr. [Eddy].
*V†.	*Cyperus ovularis* Torr. [(Michx.) Torr.].
*V†.	*Cyperus speciosus* Vahl.
V†.	*Fimbrystylis spadicea* Vahl.
V†.	*Scirpus maritimus* L.
V†.	*Scirpus pungens* Vahl. (*S. americanus* Pers.).
V.	*Juncus bufonius* L.
V†.	*Juncus canadensis* J. Gay.
V†.	*Juncus dichotomus* Ell.
V†.	*Juncus gerardi* Loisel.
V.	*Juncus scirpoides* Lam.
V†.	*Juncus tenuis* Willd.
III*a*.	*Commelyna* sp.
*VI*c*.	*Oakesia sessilifolia* Watson (*Uvularia sessilifolia* L.).
III*d*.	*Polygonatum giganteum* Dietr. (*P. commutatum* (R. and S.) Dietr.).
*III, VI†.	*Smilax glauca* Walt.
III, VI†.	*Smilax rotundifolia* L.
V*a*†.	*Iris versicolor* L.
V*a*†.	*Spiranthes cernua* Richard (*Gyrostachys cernua* (L.) Kuntze).
III*b*.	*Myrica cerifera* L.

VI*c*. *Quercus alba* L.

VI*c*. *Quercus falcata* Michx. (*Q. digitata* (Marsh), Sudworth).

*VI*c*. *Quercus tinctoria* Gray (*Q. velutina* Lam.).

VI*c*. *Quercus ilicifolia* Wang. (*Q. nana* (Marsh) Sargent).

*VII. *Polygonum acre* H. B. K. (*P. punctatum* Ell.).

VII. *Polygonum incarnatum* Watson [Ell.].

*VII. *Polygonum persicaria* L.

III*c*†. *Polygonum ramossissimum* Michx.

*III*e*, IV. *Polygonella articulata* Meisn. [L.].

*VII. *Rumex acetosella* L.

*VII. *Rumex crispus* L.

*V*e*†. *Atriplex patulum* L. var. *hastata* Gray (*A. hastata* L.).

VII. *Chenopodium album* L.

*VII†. *Chenopodium ambrosioides* L.

*VII†. *Chenopodium anthelminthicum* Gray.

V*b*†. *Salicornia ambigua* Michx.

V*b*†. *Salicornia herbacea* L.

V*b*†. *Salicornia mucronata* Bigel. (*S. Bigelovii* Torr.).

II*a* and *b*. *Salsola kali* L.

V*e*†. *Sucæda linearis* Moq. (*Dondia americana* (Pers.). Britton).

*VII. *Amaranthus paniculatus* L. (*A. hybridus paniculatus* (L.) Uline and Gray).

VII. *Amaranthus retroflexus* L.

VII. *Mollugo verticillata* L.

III*a*†. *Arenaria lateriflora* L. (*Mœhringia lateriflora* (L.) Fenzl.).

IV†. *Arenaria peploides* L. (*Ammodenia peploides* (L.) Rupr.).

IV†. *Buda marina* Dumont (*Tissa marina* (L.) Britton).

IV. *Sagina decumbens* Torr. and Gray.

*III*d*†. *Silene stellata* Ait.

VII. *Portulaca oleracea* L.

*VI*c*†. *Aquilegia canadensis* L.

V*a*†. *Ranunculus cymbalaria* Pursh. (*Oxygraphis cymbalaria* (Pursh.) Prantl).

III†.	*Sassafras officinalis* Nees (*S. sassafras* (L.) Karst).
I, II.	*Cakile americana* Nutt. (*C. edentula* (Bigel.) Hook.).
*VII†.	*Cardamine hirsuta* L.
III*a*, III*d*†.	*Geum album* Gmel. (*C. canadense* Jacq.).
*III*b*.	*Pyrus arbutifolia* L. f. (*Aronia arbutifolia* (L.) Ell.)
III.	*Prunus maritima* Wang.
*III.	*Prunus serotina* Ehrh.
*III.	*Prunus virginiana* L.
III*e*, VI*d*†.	*Rosa carolina* L.
VI*b*†.	*Rubus canadensis* L.
*VI*c*.	*Amphicarpœa monoica* Nutt. (*Falcata comosa* (L.) Kuntze).
VI*a*†.	*Cassia chamœcrista* L.
*VI*a*†.	*Cassia nictitans* L.
*VI*c*†.	*Desmodium canadense* D. C. (*Meibomia canescens* (L.) Kuntze).
VI*c*.	*Desmodium paniculatum* D. C. (*Meibomia paniculata* (L.) Kuntze).
III, VI†.	*Strophostyles angulosa* Ell. (*S. helvola* (L.) Britton).
*IV.	*Trifolium arvense* L.
*VII.	*Trifolium hybridum* L.
*VII.	*Geranium carolinianum* L.
III*d*†.	*Geranium robertianum* L.
*V*a*†.	*Linum virginianum* L.
*V*a*†.	*Polygala cruciata* L.
II, III*c*.	*Euphorbia polygonifolia* L.
III*e*†.	*Rhus copallina* L.
III*a*, VI.	*Rhus radicans* L.
III*d*.	*Ilex opaca* Ait.
*VI*d*.	*Celastrus scandens* L.
*VI*c*.	*Euonymus americanus* L.
III, VI†.	*Ampelopsis quinquefolia* Michx. (*Parthenocissus quinquefolia* (L.) Planch.).
III.	*Vitis æstivalis* Michx.
III.	*Vitis labrusca* L.
VI*d*†.	*Hibiscus moscheutos* L.
VI*d*†.	*Kosteletzkya virginica* [L.] Gray.

Va. *Hypericum mutilum* L.
*IIIc†. *Helianthemum canadense* [L.] Michx.
IIIc†. *Hudsonia tomentosa* Nutt.
IIIc. *Lechea minor* var. *maritima* Gray (*Lechea maritima* Leggett).
VIb. *Opuntia vulgaris* Mill. (*Opuntia opuntia* (L.) Coult.).
*IV. *Ludwigia palustris* Ell. (*Isnardia palustris* L.).
VII†. *Œnothera biennis* L.
Va†. *Œnothera pumila* L. (*Kneiffia pumila* (L.) Spach.).
V†. *Discopleura capillacea* D. C. (*Ptilimnium capillaceum* (Michx.) Hollick).
IIId. *Osmorrhiza* sp.
VIc. *Chimaphila maculata* [L.] Pursh.
*VIe. *Gaultheria procumbens* L.
III†. *Vaccinium corymbosum* L.
Va†. *Statice limonium* L. (*Limonium carolinianum* (Walt.) Britton).
IIIa, IIIb. *Trientalis americana* Pursh.
Va†. *Samolus valerandi* L. (*S. floribundus* H. B. K.).
Va. *Sabbatia stellaris* Pursh.
*VII. *Apocynum cannabinum* L.
*VIb. *Asclepias tuberosa* L.
IIIe†. *Asclepias incarnata* L.
IIIe†. *Calystegia sepium* L. (*Convolvulus sepium* L.).
IIIe†. *Cuscuta gronovii* Willd.
*VII. *Ipomœa purpurea* Lam. [(L.) Roth].
IIIe. *Verbena hastata* L.
*IIIe†. *Lycopus virginicus* L.
IIIe†. *Monarda punctata* L.
IIIe. *Teucrium canadense* L.
*VII. *Trichostema dichotomus* L.
VII. *Datura* sp.
*VII†. *Solanum dulcamara* L.
VII†. *Solanum nigrum* L.
Va†. *Gerardia maritima* Roi.
Va†. *Gerardia purpurea* L.
IIIe, Va†. *Linaria canadensis* [L.] Dumont.

*VII.	*Plantago major* L.
II, III.	*Diodia virginiana* L.
*III*a*, III*b*†.	*Galium circœzans* Michx.
III*a*, III*b*†.	*Galium pilosum* Ait.
VI*c*, III*a*†.	*Mitchella repens* L.
*III*e*, VI*d*.	*Sambucus canadensis* L.
III†.	*Viburnum dentatum* L.
*VI*c*.	*Sicyos angulatus* L.
VII†.	*Achillea millefolium* L.
VII†.	*Ambrosia artemisiæfolia* L.
VII.	*Ambrosia trifida* L.
VII.	*Anthemis cotula* D. C.
*VI*c*†.	*Aster diffusus* Ait. (*A. lateriflorus* (L.) Britton).
V*a*†.	*Aster subulatus* Michx.
VI*a*.	*Aster tenuifolius* L.
V*e*.	*Baccharis halimifolia* L.
*III*e*†.	*Bidens bipinnata* L.
III*e*, VI*d*.	*Cnicus horridulus* Pursh. (*Carduus spinosissimus* Walt.).
*V*e*†.	*Eclipta alba* [L.] Hassk.
V*e*†.	*Erechtites hieracifolia* Rof.
*VII†.	*Erigeron canadense* L. (*Leptilon canadense* (L.) Britton).
*VI*b*†.	*Eupatorium teucrifolium* Willd. (*E. verbenæfolium* Michx.).
*II†.	*Gnaphalium polycephalum* Michx. (*G. obtusifolium* L.).
*VI*a*.	*Gnaphalium purpureum* L.
III*e*†.	*Helianthus giganteus* L.
*VI*c*†.	*Hieracium gronovii* L.
V*e*†.	*Iva frutescens* L.
*VI*a*†.	*Kuhnia eupatorioides* L.
*VI*b*, V*c*†.	*Liatris graminifolia* Willd. (*Lacinaria cylindracea* (Michx.) Kuntze).
V*a*, V*e*†.	*Pluchea camphorata* [L.] D. C.
*VI*c*†.	*Prenanthes alba* L. (*Nabalus albus* (L.) Hook.).
*VI†.	*Sericocarpus conyzoides* Nees. (*S. asteroides* (L.) B. S. P.).
VI*c*†.	*Solidago odora* Ait.

*VIc†.	*Solidago puberula* Nutt.
Va†.	*Solidago sempervirens* L.
Va†.	*Solidago tenuifolia* Pursh. (*Euthamia caroliniana* (L.) Greene).
*VII.	*Sonchus oleraceus* L.
VII†.	*Xanthium strumarium* L.

Additional List of New Jersey Strand Plants.

The data for the following list was obtained from two sources: (1) The collections made by the writer since 1900 on the New Jersey coast, and (2) the names on the sheets in the herbarium of the late J. Bernard Brinton, M.D., now at Biological Hall, University of Pennsylvania. Those collected by the writer are unmarked, while those plants collected by Dr. Brinton are marked by an asterisk. The orders are arranged according to the system of Engler and Prantl.

Fungi.

Fuligo (*Æthalium*) *septica* Gmel. Sea Side Park.
Gymnosporangium Ellisii Berk. (on white cedar). South Sea Side Park.
Thelephora terrestris Fr. Sea Side Park.
Clitocybe trullisata Ellis. Sea Side Park.
Polyporus versicolor Fr. South Sea Side Park.
Astræus stellatus. Sea Side Park.
Lycoperdon turneri E. and E. Sea Side Park.

Musci.

Polytrichum commune L. Island Beach Life Saving Station.

Ophioglossaceæ.

**Botrychium dissectum* Spreng. Ocean Beach.
**Botrychium obliquum* Muhl. (*B. lunarioides* var. *obliquum*). Ocean Beach, Cape May.

Lycopodiaceæ.

Lycopodium carolinianum L. Island Beach Life Saving Station.

CONIFERÆ.

Chamæcyparis thyoides (L.) B. S. P. (*C. sphæroidea* Spach.). Island Beach Life Saving Station.

TYPHACEÆ.

**Typha angustifolia* L. Cape May.

GRAMINEÆ.

**Andropogon furcatus* Muhl. Anglesea.
**Elymus canadensis* L. Anglesea.
**Panicum dichotomum* L. Ocean Beach.

CYPERACEÆ.

**Carex muhlenbergii* Schk. Anglesea.
**Carex festucacea* Willd. (*C. straminea* var. *brevior* Dewey). Avalon.
**Cyperus filiculmis* Vahl. Atlantic City.
**Cyperus cylindricus* (Ell.) Britton (*C. Torreyi* Britton). Anglesea.
**Eleocharis palustris glaucescens* (Willd.) A. Gray. Anglesea.
**Eleocharis rostellata* Torr. Cape May.
Scirpus sylvaticus L.
**Stenophyllus capillaris* (L.) Britton (*Fimbrystylis capillaris* A. Gray). Anglesea.

LEMNACEÆ.

Lemna minor L. Wildwood.

IRIDACEÆ.

Iris versicolor L. Sea Side Park.

ORCHIDACEÆ.

Pogonia ophioglossoides (L.) Ker. Sea Side Park.

FAGACEÆ.

Quercus alba L. Wildwood.

ULMACEÆ.

Celtis occidentalis L. Piermont.

MORACEÆ.

Morus rubra L. Piermont.
Broussonetia papyrifera (L.) Vent. Sea Side Park, Piermont.

POLYGONACEÆ.

**Rumex patientia* L. Avalon.
**Rumex verticillatus* L.

PHYTOLACCACEÆ.

Phytolacca decandra L. Piermont.

AIZOACEÆ.

Mollugo verticillata L. Sea Side Park, Piermont.

PORTULACACEÆ.

Portulaca oleracea L. Stone Harbor.

CRUCIFERÆ.

Lepidium virginicum L. Sea Side Park.

ROSACEÆ.

**Geum canadense* Jacq. (*G. album* Gmel.).
Pyrus malus L. Sea Side Park (planted).
**Rubus villosus* Ait. Anglesea.

LEGUMINOSÆ.

**Bradburya virginiana* (L.) Kuntze (*Centrosema virginianum* Benth.). Anglesea—the only station in New Jersey.
Gleditschia triacanthos L. Sea Side Park.
Strophostyles umbellata (Muhl.) Britton (*S. peduncularis* Ell.). Sea Side Park.

ILICACEÆ.

Ilex glabra (L.) A. Gray. Sea Side Park.

ACERACEÆ.

Acer saccharinum L. (*Acer dasycarpum* Ehrh.). Sea Side Park (planted).

HYPERICACEÆ.

**Hypericum adpressum* Bart. Cape May.

CISTACEÆ.

**Lechea racemulosa* Michx. Barnegat.

CACTACEÆ.

Opuntia vulgaris Mill. (*O. opuntia* (L.) Coult.). Sea Side Park, Piermont.

ONAGRACEÆ.

Onagra biennis (L.) Scop. (*Œnothera biennis* L.). South Sea Side Park.

ERICACEÆ.

Azalea viscosa L. South Sea Side Park.
**Chimaphila maculata* (L.) Pursh. Anglesea.
Clethra alnifolia L. South Sea Side Park.
Gaylussacia resinosa [(Ait.)] T. & G.

CUSCUTACEÆ.

Cuscuta Gronovii Willd. Sea Side Park.

LABIATÆ.

**Kœllia verticellata* (Michx.) Kuntze (*Pycnanthemum Torreyi* Benth.). Ocean Beach.
Mentha spicata L. (*Mentha viridis* L.). South Sea Side Park.

SOLANACEÆ.

**Solanum nigrum* L. Atlantic City.

SCROPHULARIACEÆ.

**Gerardia tenuifolia* Vahl. Cape Ann, Mass.
Linaria canadensis (L.) Dumont. Sea Side Park.

BIGNONIACEÆ.

Tecoma radicans (L.) D. C. Piermont.

RUBIACEÆ.

**Cephalanthus occidentalis* L. Anglesea.
**Galium pilosum* Ait. Anglesea.
**Galium trifidum* L. Cape May.
Mitchella repens L. Wildwood.

COMPOSITÆ.

**Aster multiflorus* Ait. Anglesea.
**Aster nova belgii* L. var. *litoreus* A. Gray. Avalon.
**Aster patens* L. Ocean Beach.
**Aster surculosus* Michx. Ocean Beach.
**Dœllingeria umbellata* (Mill.) Nees. (*Aster umbellatus* Mill.). Ocean Beach.
Eupatorium perfoliatum L. South Sea Side Park.
Euthamia caroliniana (L.) Greene (*Solidago tenuifolius* Pursh.). Sea Side Park.
Helenium autumnale L. Sea Side Park.
Helianthus sp. Sea Side Park.
**Hieracium scabrum* Michx. Anglesea.
Lactuca scariola L. South Sea Side Park.
**Rudbeckia hirta* L. Anglesea.
Solidago puberula Nutt. South Sea Side Park.